

Claims

1. A regenerative photoelectrochemical cell comprising a photoanode, said photoanode comprising at least one semi-conductive metal oxide layer on a conductive substrate, sensitized by a photosensitizer dye, a counter electrode and an electrolyte arranged between said semi-conductive metal oxide layer and said counter electrode, characterized in that an amphiphilic compacting compound whose molecular structure comprises at least one anchoring group, a hydrophobic portion and a terminal group is co-adsorbed with said photosensitizing dye on said semi-conductive metal oxide layer in a mixed monolayer.

2. A cell as claimed in claim 1, characterized in that said photosensitizing dye and said compacting compound form a self-assembled mixed monolayer on said semi-conductive metal oxide layer, wherein the molar ratio of said photosensitizing dye to said co-adsorbed compacting compound is of between 10 and 1/2, in particular of between 5 and 1.

3. A cell as claimed in claim 2, characterized in that said self-assembled monolayer is a dense packed monolayer having an order-disorder transition temperature above 80° C.

4. A cell as claimed in anyone of the preceding claims, characterized in that said anchoring group of said compacting compound is selected from the group consisting of COOH, PO₃H₂, PO₄H₂, SO₃H₂, SO₄H₂, CONHOH⁻ and deprotonated forms thereof.

5. A cell as claimed in anyone of claims 1 to 3, characterized in that said anchoring group of said compacting compound is a chelating group with Π -conducting character, in particular an oxyme, dioxyme, hydroxyquinoline, salicylate or α -keto-enolate group.

6. A cell as claimed in anyone of the preceding claims, characterized in that said terminal group of the compacting compound is a neutral group selected from alkyl, alkenyl,

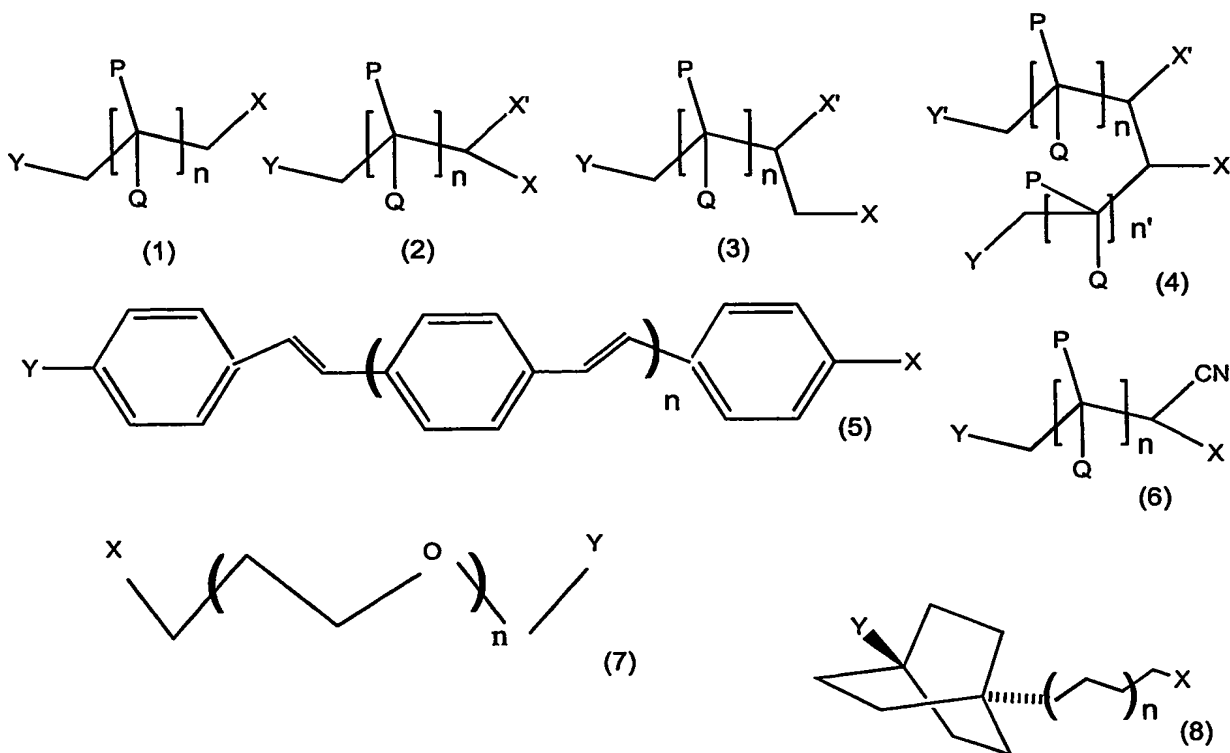
alkynyl, alkoxy or poly-ether chain and branched alkyls, and carbon atoms substituted by several cycloalkyl or phenyl groups.

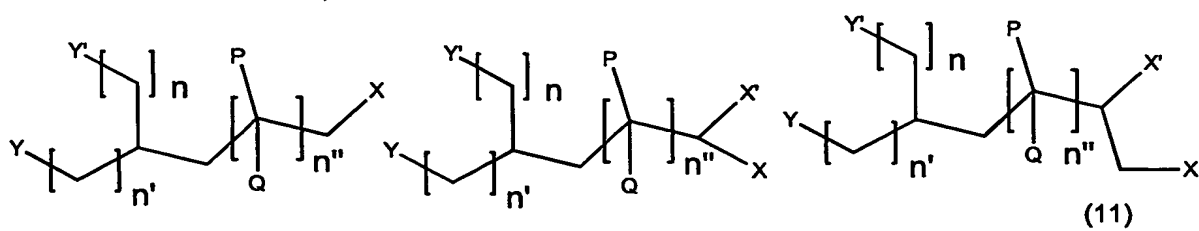
7. A cell as claimed in anyone of claims 1 to 5, characterized in that said terminal group is an anionic group selected from the group consisting of SO_3^- , CO_2^- , PO_3^{2-} , PO_3H^- and CONHO^- .

8. A cell as claimed in anyone of claims 1 to 5, characterized in that said terminal group is a cationic group selected from ammonium, phosphonium and sulfonium groups.

9. A cell as claimed in anyone of the preceding claims, characterized in that the length of said hydrophobic chain portion of the compacting compound allows said terminal group to protrude above the sensitizing dye in said monolayer.

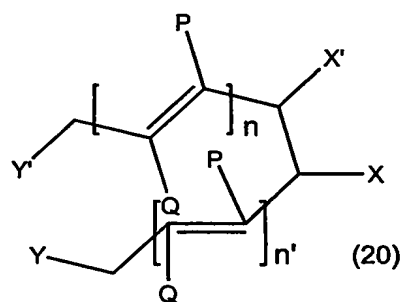
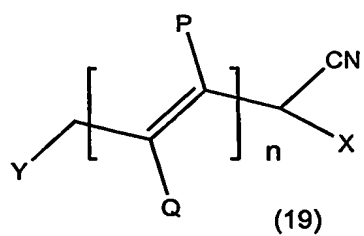
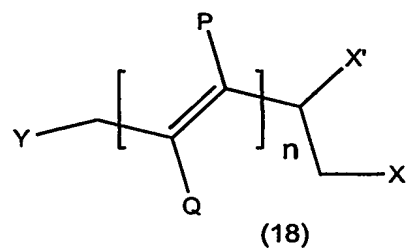
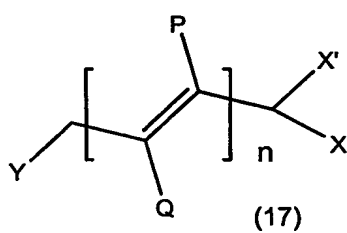
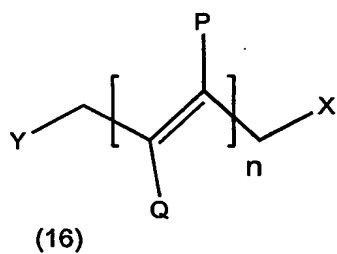
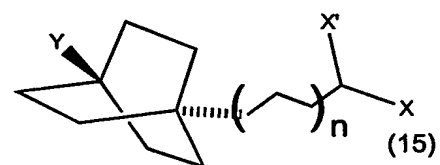
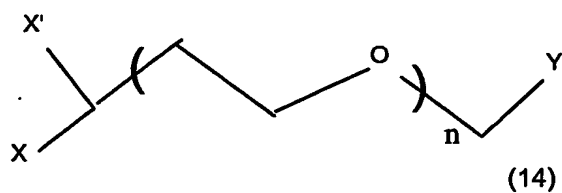
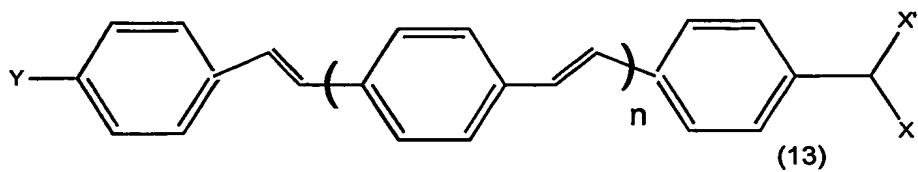
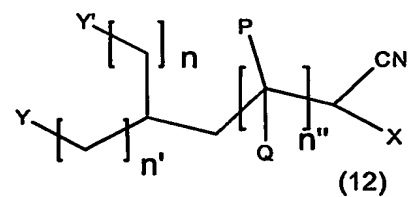
10. A cell as claimed in claim 1, characterized in that said compacting compound is selected from the group of compounds having one of formulae (1) to (27):

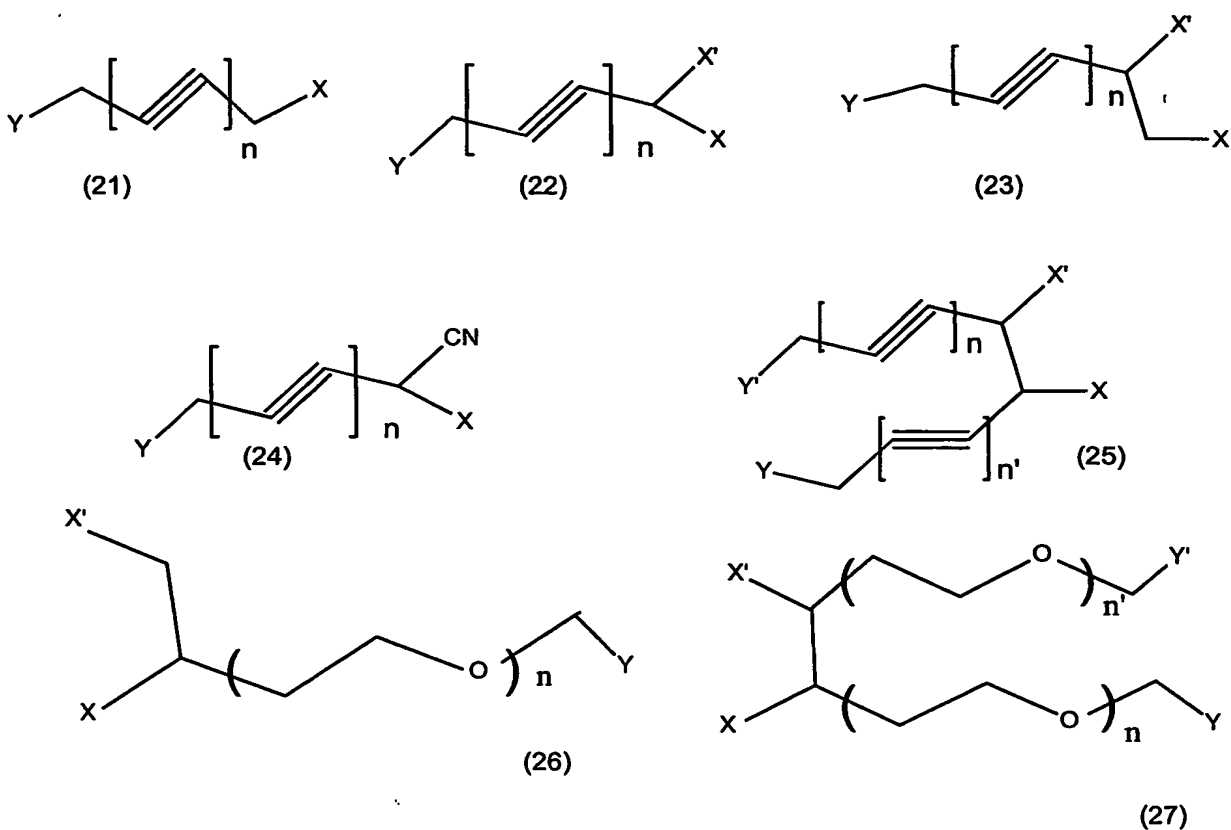




(9)

(10)





With the proviso that

$P = Q = H$ (hydrogen)

or $P = H$ and $Q = F$ (fluoride)

or $P = Q = F$

that

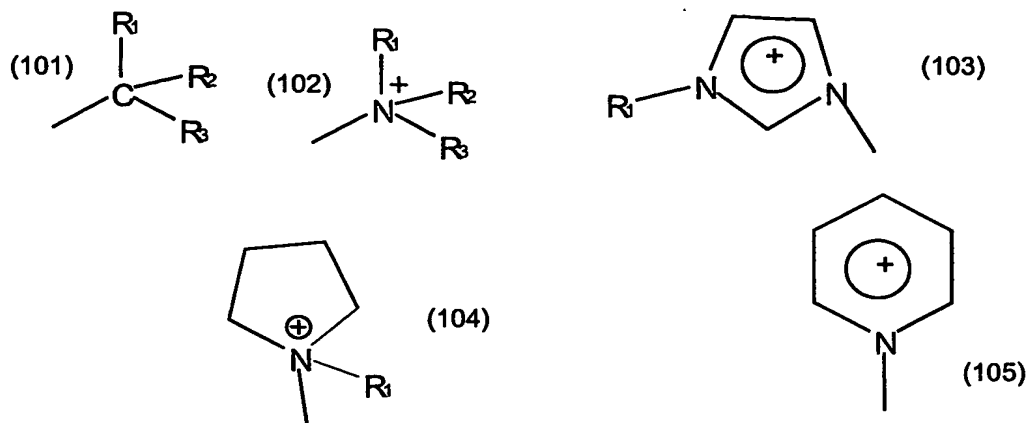
X and X' are, independently one from the other, one of the groups SO_3^- , CO_2^- , PO_3^{2-} , PO_3H^- and $CONHO^-$

that

n , n' and n'' designate the same or different integers from 1 to 20

that

Y and Y' are, independently one from the other, one of the groups SO_3^- , CO_2^- , PO_3^{2-} , PO_3H^- and $CONHO^-$ or a group having one of formulae (101) to (105)



Wherein R_1 , R_2 , R_3 designate independently one from the other H, a phenyl group or an alkyl group of 1 to 20 carbon atoms.

11. A cell as claimed in claim 1, characterized in that said compacting compound is selected from the group consisting of alkyl carboxylic acids, alkyl dicarboxylic acids, alkyl carboxylates, alkyl phosphonic acids, alkyl phosphonates, alkyl diphosphonic acids, alkyl diphosphonates, alkyl sulphonic acids, alkyl sulphonates, alkyl hydroxamic acids and alkyl hydroxamates, wherein alkyl is linear or branched from C1 to C20.

12. A cell as claimed in claim 1, characterized in that said compacting compound is selected from cyclohexane-carboxylic acid, adamantane acetic acid, adamantane propionic acid and 4-pentylbicyclo(2,2,2)-octane-1-carboxylic acid.

13. A cell according to anyone of the preceding claims, characterized in that said sensitizing dye is a ruthenium, osmium or iron complex with ligands selected from bidentate, tridentate and polydentate polypyridil compounds and at least one anchoring group.

14. A cell according to anyone of the preceding claims, characterized in that said sensitizing dye is an amphiphilic ruthenium polypyridil complex.

15. A cell as claimed in anyone of the preceding claims, characterized in that said sensitizing dye is a Ru(II) complex of formula RuLL' (NCS)_2 , in which L represents the ligand 4,4'-dicarboxylate-2,2'-bipyridine and L' represents the ligand 4,4'-nonyl-2,2'-bipyridine.

16. A cell as claimed in anyone of the preceding claims, characterized in that said electrolyte comprises an effective gelifying amount of a gelifying compound.

17. A cell as claimed in claim 16, characterized in that said gelifying compound is a matrix forming polymer.

18. A cell as claimed in claim 17, characterized in that said polymer is selected from the group consisting of polyvinylidene fluoride (PVDF), polyvinylidene-hexafluoropropylene (PVD-HFP), polyvinylidene-hexafluoropropylene-chlorotrifluoroethylene (PVD+HFP+CTFE) copolymers, polyethylene oxide, polymethylmethacrylate, polyacrylonitrile, polypropylene, polystyrene, polybutadiene, polyethyleneglycol, polyvinylpyrrolidone, polyaniline, polypyrrole, polythiophene and derivatives thereof.

19. A cell as claimed in anyone of the preceding claims, characterized in that said electrolyte comprises a copolymer of polyvinylidene fluoride-hexafluoropropylene (PVDF-HFP) and in that the amount of said PVDF-HFP copolymer is of between 2 % and 50 % by weight of the electrolyte.

20. A cell as claimed in claim 16, characterized in that said gelifying compound is selected from the group consisting of SiO_2 , TiO_2 and Al_2O_3 nanoparticles, MgO and TiO_2 nano-tubes, TiO_2 nano-rods, wherein the gel contains said gelifying compound in minor proportions, of between 2 % and 20 % by weight of the electrolyte, in particular 10 Wt %.

21. A cell as claimed in anyone of the preceding claims, characterized in that said electrolyte comprises a redox system and said redox system comprises an electrochemically active salt and a first compound forming a redox couple with either the anion or the cation of said electrochemically active salt.

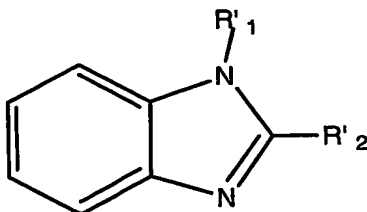
22. A cell as claimed in anyone of the preceding claims, characterized in that said electrolyte comprises a room temperature molten salt, said molten salt being liquid at least between standard room temperature and 80°C above said room temperature.

23. A cell as claimed in anyone of the preceding claims, characterized in that said electrolyte further comprises a polar organic solvent having a boiling point of 100°C or greater than 100°C at normal atmospheric pressure.

24. A cell as claimed in claim 23, characterized in that said solvent is a nitrile selected from 3-methoxypropionitrile and butyronitrile.

25. A cell as claimed in anyone of the preceding claims, characterized in that said electrolyte further comprises, as an additive, a compound formed by a neutral molecule comprising one or more nitrogen atom(s) with a lone electron pair.

24. A cell as claimed in claim 25, characterized in that said neutral molecule has following formula:



wherein R'₁ and R'₂ can be H, alkyl, alkoxyl, alkenyl, alkynyl, alkoxyl, poly-ether, and/or phenyl, independently one

from the other, the number of carbon atoms of each substituent ranging from 1 to 20, the substitute being linear or branched.